

A. Georges Bank Atlantic Cod by L. O'Brien , N. J. Munroe, L. Col

1.0 Background

This stock was last assessed and peer reviewed in October 2002 (O'Brien *et al.* 2002). Landings were 12,769 mt in 2001 and fully recruited F (ages 4-8, unweighted average) was estimated to be 0.38 in 2001, the second lowest F in the time series (1978-2000). Spawning stock biomass was 29,170 mt in 2001 and continued the increasing trend from the record low estimate of 17,375 mt in 1995. Since 1991, recruiting year classes have all been below the long term average and the 2000 and 2001 year classes were the lowest in the time series. The NEFSC spring and autumn bottom trawl survey indices continued to remain near record low values. Autumn recruitment indices for age 2 fish from the 1994 through 1998 year classes were all below the time series (1963-2000) average. The most recent above average autumn recruitment index occurred in 1993.

The current assessment presented here is considered an update and the methodology has remained the same as in the 2002 assessment (O'Brien *et al.* 2002).

2.0 Fishery

Total commercial landings of Georges Bank cod (Table A1, Figure A1) decreased 20% in 2002 to 10,274 mt, 22% in 2003 to 7,963 mt, and 42% in 2004 to a record-low 4,583 mt. USA landings decreased 67% (3,471mt) and Canadian landings decreased 48% (1,112mt) in 2004 relative to 2001 landings (Table A1). Recreational landings were estimated at 346 mt in 2004, an 11% increase from 2003.

USA landings were dominated in weight by age 4 in 2002, and by age 5 in 2003 and 2004. Canadian landings were dominated in weight by the 1998 year class at age 4 in 2002, at age 5 in 2003 and at age 6 in 2004.

3.0 Research Surveys

NEFSC spring and autumn survey biomass and abundance indices have fluctuated during 2002 to 2005, but continue to remain below the long term average (Table A2, Figure A2-A3). The recruitment indices for age 1 from the NEFSC 2004 autumn bottom trawl survey indicate that the 2003 year class , while below average, is still the strongest since 1992 (Table A3, Fig.A4). The age 0 index is not generally used as an indicator of year class strength, however, the 2004 index is well above average and the highest since the 1975 year class. The Canadian 2004 spring survey index of abundance for age 1 indicated that the 2003 year class was above average (Table A3, Figure A5). The 2005 Canadian indices are not representative since the survey did not cover all of the Georges Bank strata.

4.0 Assessment

Input data and Analyses

The current assessment is an update assessment and employs the same VPA formulation as in the 2001 assessment (O'Brien *et al.* 2002). A slight variation from the previous assessment is that the number of surveys available as tuning indices in the terminal year is decreased from three to two since the DFO 2005 spring survey did not sample the entire Georges Bank strata due to mechanical problems.

Catch at age (1-10+) has been updated with total 2004 landings (USA and Canadian). The USA commercial port sampling for this stock has increased from 1 sample per 104 mt landed in 2002, to 1 sample per 68 mt landed in 2003, and 1 sample per 27 mt in 2004. Samples were well distributed between quarters, so that quarterly catch at age by market category could be estimated without pooling (Table A4). Spatial coverage was poor for eastern Georges Bank (SA 561, 562), as it has been for several years. As in the last assessment, additional length samples from western Georges Bank and combined US and Canadian age samples from eastern Georges Bank were applied to characterize the landings from eastern Georges Bank. The catch at age includes total landings from both the USA and Canadian fisheries (Table A5).

Discards at age were estimated using the Observer Database from 1989-2004. A discard to kept ratio was applied to landings to estimate total discards (mt), and total discards at length were estimated from sampled length frequencies of observed tows. The age composition of the discarded length frequency was estimated using a combination of commercial data for all ages and research survey data for ages 1-3 only.

Research survey indices have been estimated for the 2002-2005 NEFSC and 2002-2004 Canadian Department of Fisheries and Oceans (DFO) spring (ages 1-8) bottom trawl surveys and the NEFSC 2002-2004 autumn (ages 1-6) bottom trawl survey (Table A3). The ADAPT calibration method (Parrack 1986), (Gavaris 1988), (Conser and J.E. Powers. 1990) was used to derive estimates of instantaneous fishing mortality and beginning year stock sizes in 2004. A conditional non-parametric bootstrap procedure (Efron 1982) was used to evaluate the precision of fishing mortality and spawning stock biomass. A retrospective analysis was performed for terminal year fishing mortality, spawning stock biomass, and age 1 recruitment.

Assessment results

Fully recruited fishing mortality (ages 4-8) was estimated at 0.24 in 2004 (Table A6, Figure A6). Spawning stock biomass in 2004 was estimated at 22,564 mt, a 25% decrease from 2001 but a 23% increase from the record low in 1995 (Table A6, Figure A7). Recruitment (millions of age 1 fish) of the 2004 year class (10.4 million) is estimated to be similar to the 1998 year class (12.8 million) (Table A6, Figure A7). Recruitment of the 2003 year class (21.2 million) is the first year class estimated above the long-term average (1977-2003) of 14.7 million fish. The survival ratio of recruit/SSB was above average for the 2003 and 2004 year classes (Figure A8).

VPA Diagnostics

Stock size estimates for ages 1-8 were well estimated with CVs ranging from 0.29 to 0.57 (Appendix A2). The distribution of F estimates from the bootstrap analysis ranged from 0.14 to 0.31 with an 80% probability that F in 2004 was between 0.17 and 0.26. The distribution of SSB estimates from the bootstrap analysis ranged from 16,721 mt to 30,137 mt with an 80% probability that SSB in 2004 was between 19,704 mt to 27,122 mt.

The strong retrospective pattern present in the previous assessment (O'Brien *et al.* 2002) with this model formulation is not as evident for the most current years (Figure A9). The terminal year estimates of fishing mortality were the same for 2004 and 2003, but are then less than the converged estimates from 1994-2002. SSB estimates were similar for 2000-2004, but are greater than converged estimates from 1994-1999. The pattern in the terminal year estimates of recruits are generally less than converged estimates.

Sensitivity Analyses

Analyses were conducted to determine the sensitivity of fishing mortality and spawning stock biomass estimates to the addition of discards to the catch at age. Differences in F are minimal with F being slightly higher, and SSB slightly lower than the base run estimates when discards are included in the catch at age.

5.0 Biological Reference Points

Biological reference points were established for Georges Bank cod based on a Beverton-Holt stock recruit model (NEFSC 2002.) as:

$$\begin{aligned} \text{MSY} &= 35,236 \text{ mt} \\ \text{SSB}_{\text{MSY}} &= 216,780 \text{ mt and} \\ F_{\text{MSY}} &= 0.175 \end{aligned}$$

In 2004, spawning stock biomass was estimated at 22,564 mt, about 10% of the target SSB_{MSY}. The stock is considered to be overfished. F was estimated at 0.24, therefore overfishing is occurring on this stock.

6.0 Summary

Georges Bank Atlantic cod are overfished and overfishing is occurring. Fishing mortality has been steadily declining since 1997, except for a slight increase in 2001, and is currently at the lowest exploitation in the time series. Spawning stock biomass reached a record low in 1995 and slowly increased, primarily due to growth ,until 2001. Since 2001, however, SSB has been declining. The 2002-2004 F trajectory is less than that projected for A13 and the SSB is slightly higher than the A13 projection (Figure A10). Catch during 2002-2004 was also less than the A13 projection.

The 1999 and 1998 year class accounts for the majority of the US catch and the 1998 year class

accounts for the majority of the Canadian catch in 2004. The 1998 (12.8 million age 1 fish) year class, while below the long term average (14.7 million age 1 fish), represents the strongest year class since the last above-average year class that occurred in 1990 (17.8 million age 1 fish). The 2000, 2001, and 2002 year classes are among the lowest in the time series. The 2003 (21.2 million age 1 fish) year class is the first above average year class since the 1990 and will enter the fishery during 2005.

The NEFSC and DFO survey biomass and abundance indices fluctuated during 2002 to 2005, however, all the indices continue to remain below the long term average. The most recent NEFSC surveys indicate that the 2003 year class may be similar in size to the 1998 year class, and the DFO spring survey indicates that the year class is above average.

The lack of strong recruitment in the last decade suggests that recovery of this stock will be largely dependent on reducing fishing mortality in the near term and husbanding the strong 2003 year class, and potentially the 2004 year class, to increase SSB.

7. 0 Sources of Uncertainty

Landings data for 1994-2004 are derived by proration and are provisional.

Estimation of eastern Georges Bank landings are derived on small number of samples supplemented by western length frequency and Canadian age data. Increased sampling of landings in statistical areas 561-562 would be an improvement.

The 2004 NMFS fall survey index for age 0 may be optimistic.

8.0 Panel Discussion

The NMFS fall 2004 survey had the highest age 0 index since the 1975 year class. The panel discussed whether the high number of age 0 cod in 2004 was a sampling artifact. An examination of catch locations indicated that age 0 cod were caught in multiple tows in 2004, but were highly localized. Additionally, the NMFS spring survey age 1 and age 2 indices in 2005 were lower than the fall 2004 age 0 and age 1 indices respectively, indicating a possible year effect. The panel decided to not use the age 1 index for 2005 in the projections based on the uncertainty of the index. Concern was also expressed that the mean weight and number per tow at age generally increased in 2004 over all ages. It was recommended that confidence intervals be examined for NMFS survey indices.

Lower abundance indices were observed in the Canadian DFO spring 2005 survey; however there is uncertainty in these data due to incomplete surveying and vessel changes. It was noted that a conversion factor needs to be calculated between the Canadian R/V Needler and R/V Teleost in order to use the Canadian spring 2005 indices. At the present time it was concluded that the 2005 Canadian survey will not be used in the VPA input for 2004.

In recent years, there has been a decline in mean weight at age of older fish in commercial fishery catches. It was discussed whether this could be due to small sample sizes of older ages in

the U.S. commercial data, however the decline was consistent over all older ages. Mean weight at age has also been declining for older fish in the Canadian surveys, indicating possible lower productivity in the stock for recent years.

The recommendation was made that discards and recreational catches be included in future catch at age input data to account for all removals. For this assessment, discards and recreational catches were not included in order to be consistent with 2002 reference points, however, a sensitivity run with discards was presented which did not show substantial differences from the base run.

The mean F is currently estimated as an average of ages 4-8, however, since 1994 the landings of age groups 7 and 8 have declined. The panel discussed that an F averaged over ages 4-6 may be more representative of the current age structure of the landings.

The panel noted that trends in partial recruitment need to be examined since this could change the estimation of reference points. A three year average was agreed to be sufficient for the present time since the projections are only going to be made over a four-year period.

Projection Determination:

Recruitment at age 1 in 2005 will be estimated from the stock recruitment relationship. Mean weights at age will be averaged over the last three years in order to account for declining mean weights at age in older ages. Maturity ogive and partial recruitment will be averaged over the last three years as well.

Research Recommendations:

Examine variances of NMFS survey mean weights and mean numbers per tow by year, especially for 2004.

Include discards and recreational catches in the catch at age.

Examine changes in partial recruitment and explore the effect of estimating average F for age groups 4-6 compared to the current average F for ages 4-8.

9.0 References

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Table A1. Commercial landings (metric tons, live) of Atlantic cod from the Georges Bank and South (NAFO Division 5Z and Subarea 6) stock, 1960–2004 (* = Provisional data).

Country							
Year	USA	Canada	USSR	Spain	Poland	Other	Total
1960	10834	19	-	-	-	-	10853
1961	14453	223	55	-	-	-	14731
1962	15637	2404	5302	-	143	-	23486
1963	14139	7832	5217	-	-	1	27189
1964	12325	7108	5428	18	48	238	25165
1965	11410	10598	14415	59	1851	-	38333
1966	11990	15601	16830	8375	269	69	53134
1967	13157	8232	511	14730	-	122	36752
1968	15279	9127	1459	14622	2611	38	43136
1969	16782	5997	646	13597	798	119	37939
1970	14899	2583	364	6874	784	148	25652
1971	16178	2979	1270	7460	256	36	28179
1972	13406	2545	1878	6704	271	255	25059
1973	16202	3220	2977	5980	430	114	28923
1974	18377	1374	476	6370	566	168	27331
1975	16017	1847	2403	4044	481	216	25008
1976	14906	2328	933	1633	90	36	19926
1977	21138	6173	54	2	-	-	27367
1978	26579	8778	-	-	-	-	35357
1979	32645	5978	-	-	-	-	38623
1980	40053	8063	-	-	-	-	48116
1981	33849	8499	-	-	-	-	42348
1982	39333	17824	-	-	-	-	57157
1983	36756	12130	-	-	-	-	48886
1984	32915	5763	-	-	-	-	38678
1985	26828	10443	-	-	-	-	37271
1986	17490	8504	-	-	-	-	25901
1987	19035	11844	-	-	-	-	30880
1988	26310	12741	-	-	-	-	39242
1989	25097	7895	-	-	-	-	33098
1990	28193	14364	-	-	-	-	42503
1991	24175	13462	-	-	-	-	37630
1992	16855	11673	-	-	-	-	28567
1993	14594	8524	-	-	-	-	23113
1994	9893	5278	-	-	-	-	15169
1995	6759	1100	-	-	-	-	7859
1996	7020	1926	-	-	-	-	8905
1997	7537	2919	-	-	-	-	10435
1998	6959	1908	-	-	-	-	8832
1999	8061	1819	-	-	-	-	9880
2000	7617	1572	-	-	-	-	9189
2001	10635	2143	-	-	-	-	12778
2002	8998	1276	-	-	-	-	10274
2003	6646	1317	-	-	-	-	7963
2004	3471	1112	-	-	-	-	4583

Table A2. Standardized stratified mean catch per tow in numbers and weight (kg) for Atlantic cod in NEFSC offshore spring and autumn research vessel bottom trawl surveys on Georges Bank (Strata 13-25), 1963 - 2005. [1,2,3]

Year	Spring		Autumn	
	No/Tow	Wt/Tow	No/Tow	Wt/Tow
1963	-	-	4.37	17.8
1964	-	-	2.79	11.4
1965	-	-	4.25	11.8
1966	-	-	4.90	8.1
1967	-	-	10.33	13.6
1968	4.73	12.7	3.31	8.6
1969	4.63	17.8	2.24	8.0
1970	4.34	15.8	5.12	12.6
1971	3.39	14.3	3.19	9.8
1972	9.16	19.3	13.09	22.9
1973	57.81	94.5	12.28	30.9
1974	14.74	36.4	3.49	8.2
1975	6.89	26.1	6.41	14.1
1976	7.06	18.6	10.43	17.7
1977	6.19	15.3	5.44	12.5
1978	12.31	31.2	8.59	23.3
1979	5.00	16.2	5.95	16.5
1980	7.68	24.1	2.91	6.7
1981	10.44	26.1	9.20	20.3
1982	32.96	101.9	3.34	6.1
1983	7.70	23.5	4.14	6.1
1984	4.08	15.3	4.73	10.0
1985	7.03	21.7	2.31	3.1
1986	5.04	16.7	2.99	3.7
1987	3.24	9.9	2.33	4.4
1988	5.87	13.5	3.07	5.6
1989	4.80	10.9	4.84	4.7
1990	4.79	11.7	4.78	11.5
1991	4.31	8.9	0.96	1.4
1992	2.67	7.4	1.72	3.0
1993	2.40	7.0	2.15	2.2
1994	0.95	1.2	1.82	3.3
1995	3.29	8.4	3.62	5.6
1996	2.70	7.5	1.10	2.7
1997	2.32	5.2	0.87	1.9
1998	4.36	11.7	1.87	2.8
1999	2.15	4.7	1.02	3.0
2000	3.57	8.2	1.31	1.4
2001	1.86	5.5	1.05	2.1
2002	2.08	5.0	4.70	11.3
2003	1.98	4.2	1.25	2.1
2004	5.38	14.3	4.21	5.9
2005	1.96	4.5		
1963-2004 Average	7.3	18.7	4.30	9.0

[1] During 1963-1984, BMV oval doors used in spring and autumn surveys; since 1985, Portuguese polyvalent doors used in both surveys.

Adjustments have been made to the 1963-1984 catch per tow data to standardize these data to polyvalent door equivalents.

Conversion coefficients of 1.56 (numbers) and 1.62 (weight) were used in this standardization (NEFC 1991).

[2] Spring surveys during 1980-1982, 1989-1991 and 1994 and autumn surveys during 1977-1981, 1989-1991, and 1993 were accomplished with the R/V Delaware II; in all other years, the surveys were accomplished using the R/V Albatross IV. Adjustments have been made to the R/V Delaware II catch per tow data to standardize these to R/V Albatross IV equivalents.

Conversion coefficients of 0.79 (numbers) and 0.67 (weight) were used in this standardization (NEFC 1991)

[3] Spring surveys during 1973-1981 were accomplished with a '41 Yankee' trawl; in all other years, spring surveys were accomplished with a 36 Yankee' trawl. No adjustments have been made to the catch per tow data for these gear differences.

Table A3. Standardized (for vessel and door changes) stratified mean catch per tow at age (numbers) of Atlantic cod in NEFSC offshore spring and autumn bottom trawl surveys on Georges Bank (Strata 13-25), 1963 - 2005.

Year SPRING	AGE											No./tow
	0	1	2	3	4	5	6	7	8	9	10+	
1968	0.513	0.136	1.615	0.825	0.665	0.385	0.246	0.140	0.083	0.056	0.058	4.722
1969	0.000	0.123	0.546	1.780	0.888	0.451	0.326	0.215	0.128	0.072	0.112	4.641
1970	0.000	0.338	0.804	0.430	1.241	0.162	0.844	0.263	0.058	0.056	0.147	4.342
1971	0.000	0.206	0.860	0.438	0.254	0.570	0.114	0.324	0.365	0.128	0.132	3.391
1972	0.056	3.000	1.838	2.732	0.445	0.166	0.323	0.084	0.285	0.071	0.158	9.159
1973	0.056	0.546	42.258	6.344	6.387	0.657	0.515	0.367	0.058	0.217	0.404	57.808
1974	0.000	0.444	4.558	5.971	0.761	1.988	0.442	0.100	0.265	0.064	0.144	14.735
1975	0.000	0.064	0.327	2.092	2.941	0.377	0.744	0.084	0.115	0.147	0.000	6.890
1976	0.111	1.298	1.955	0.915	0.661	1.607	0.153	0.261	0.029	0.000	0.068	7.058
1977	0.000	0.044	3.389	1.084	0.553	0.267	0.717	0.052	0.066	0.000	0.021	6.193
1978	3.312	0.372	0.192	5.531	0.972	0.778	0.142	0.712	0.065	0.141	0.096	12.312
1979	0.108	0.428	1.298	0.275	1.852	0.547	0.236	0.084	0.139	0.013	0.022	5.000
1980	0.105	0.031	2.217	2.690	0.212	1.705	0.374	0.186	0.031	0.030	0.096	7.676
1981	0.301	2.302	1.852	2.811	1.685	0.106	0.879	0.258	0.132	0.000	0.113	10.438
1982	0.169	0.508	5.435	9.502	8.324	6.208	0.293	1.866	0.369	0.082	0.203	32.958
1983	0.081	0.332	1.952	3.017	0.796	0.697	0.443	0.027	0.219	0.000	0.138	7.701
1984	0.000	0.402	0.431	0.761	1.238	0.422	0.400	0.209	0.000	0.215	0.000	4.078
1985	0.244	0.111	2.653	0.663	1.110	1.412	0.265	0.192	0.180	0.037	0.161	7.029
1986	0.092	0.872	0.409	1.844	0.365	0.540	0.618	0.062	0.125	0.101	0.015	5.044
1987	0.000	0.020	1.613	0.378	0.763	0.062	0.179	0.136	0.033	0.027	0.025	3.235
1988	0.180	0.720	0.609	3.150	0.409	0.644	0.064	0.037	0.049	0.000	0.007	5.868
1989	0.000	0.310	1.410	0.666	1.583	0.235	0.351	0.051	0.040	0.055	0.093	4.794
1990	0.042	0.173	0.922	1.737	0.674	0.912	0.130	0.143	0.013	0.016	0.027	4.790
1991	0.195	1.027	0.528	0.689	0.929	0.479	0.328	0.054	0.041	0.000	0.045	4.313
1992	0.000	0.123	1.252	0.468	0.168	0.273	0.142	0.159	0.020	0.037	0.028	2.670
1993	0.110	0.009	0.399	1.306	0.205	0.090	0.138	0.029	0.034	0.021	0.055	2.396
1994	0.030	0.125	0.272	0.200	0.217	0.033	0.006	0.044	0.000	0.019	0.000	0.945
1995	0.482	0.050	0.382	0.854	0.534	0.599	0.107	0.234	0.028	0.022	0.000	3.290
1996	0.000	0.073	0.214	0.736	1.247	0.174	0.209	0.028	0.018	0.000	0.000	2.699
1997	0.302	0.291	0.437	0.170	0.489	0.422	0.050	0.134	0.020	0.000	0.000	2.315
1998	0.018	0.111	0.665	1.298	0.848	0.755	0.533	0.102	0.031	0.000	0.000	4.360
1999	0.067	0.212	0.291	0.609	0.510	0.238	0.119	0.064	0.031	0.007	0.000	2.148
2000	0.053	0.221	0.807	0.830	1.141	0.370	0.102	0.026	0.020	0.000	0.000	3.569
2001	0.000	0.061	0.235	0.794	0.160	0.383	0.177	0.023	0.018	0.012	0.000	1.862
2002	0.018	0.065	0.093	0.383	0.993	0.239	0.225	0.039	0.000	0.000	0.028	2.083
2003	0.000	0.016	0.213	0.271	0.623	0.696	0.064	0.080	0.012	0.000	0.000	1.975
2004	0.000	0.637	0.058	0.579	1.407	1.354	0.893	0.179	0.261	0.013	0.000	5.380
2005	0.0614	0.0119	0.4838	0.1378	0.631	0.2744	0.2053	0.1274	0.0298	0		1.9628
average	0.289	0.427	2.297	1.752	1.196	0.730	0.321	0.190	0.099	0.066	0.096	7.294

Table A3 continued. Standardized (for vessel and door changes) stratified mean catch per tow at age (numbers) of Atlantic cod in NEFSC offshore spring and autumn bottom trawl surveys on Georges Bank (Strata 13-25), 1963 - 2004.

Year	AGE										No./tow
	0	1	2	3	4	5	6	7	8	9	
AUTUMN											
1963	0.019	0.719	0.778	0.920	0.897	0.354	0.326	0.175	0.103	0.014	0.069
1964	0.009	0.640	0.699	0.588	0.538	0.145	0.136	0.062	0.050	0.030	0.083
1965	0.173	1.299	0.998	0.707	0.484	0.167	0.179	0.112	0.081	0.023	0.023
1966	1.025	1.693	1.000	0.515	0.264	0.100	0.095	0.062	0.039	0.002	0.017
1967	0.072	7.596	1.334	0.523	0.406	0.133	0.133	0.055	0.051	0.012	0.070
1968	0.070	0.314	1.611	0.783	0.271	0.073	0.067	0.027	0.023	0.008	0.048
1969	0.000	0.343	0.622	0.626	0.331	0.094	0.061	0.019	0.023	0.022	0.059
1970	0.434	1.699	1.361	0.532	0.696	0.153	0.000	0.033	0.055	0.055	0.098
1971	0.400	0.602	0.617	0.408	0.310	0.478	0.164	0.042	0.090	0.000	0.075
1972	0.948	7.473	1.191	1.841	0.399	0.241	0.568	0.116	0.204	0.021	0.084
1973	0.203	1.748	6.060	1.164	2.039	0.210	0.225	0.175	0.062	0.137	0.253
1974	0.461	0.410	0.667	1.509	0.161	0.089	0.112	0.000	0.059	0.021	0.000
1975	2.377	0.992	0.421	0.628	1.682	0.111	0.156	0.000	0.000	0.000	0.037
1976	0.000	6.144	2.073	0.762	0.275	0.738	0.054	0.269	0.037	0.052	0.021
1977	0.152	0.237	3.434	0.691	0.253	0.173	0.394	0.007	0.027	0.000	0.077
1978	0.395	1.845	0.391	4.058	0.964	0.336	0.165	0.343	0.050	0.030	0.014
1979	0.115	1.625	1.677	0.162	1.687	0.321	0.184	0.031	0.113	0.010	0.025
1980	0.280	0.820	0.564	0.774	0.053	0.265	0.057	0.067	0.027	0.000	0.000
1981	0.261	3.525	2.250	1.559	0.589	0.054	0.579	0.057	0.064	0.018	0.083
1982	0.362	0.577	1.910	0.242	0.068	0.115	0.000	0.031	0.033	0.000	0.000
1983	1.283	0.850	1.089	0.740	0.069	0.033	0.004	0.010	0.015	0.000	0.044
1984	0.179	1.909	0.682	0.929	0.825	0.024	0.059	0.039	0.000	0.039	0.044
1985	1.002	0.181	0.843	0.067	0.106	0.077	0.028	0.000	0.000	0.000	0.003
1986	0.076	2.279	0.129	0.329	0.008	0.049	0.073	0.016	0.000	0.007	0.022
1987	0.204	0.414	1.353	0.108	0.200	0.028	0.012	0.000	0.000	0.000	0.007
1988	0.550	0.875	0.437	0.904	0.060	0.194	0.000	0.011	0.039	0.000	0.000
1989	0.251	2.798	1.046	0.161	0.507	0.055	0.015	0.007	0.000	0.000	0.000
1990	0.157	0.364	1.624	1.814	0.412	0.286	0.069	0.022	0.011	0.000	0.022
1991	0.041	0.408	0.175	0.274	0.031	0.029	0.000	0.000	0.000	0.000	0.057
1992	0.035	0.412	0.949	0.174	0.100	0.044	0.010	0.000	0.000	0.000	0.000
1993	0.178	0.970	0.532	0.383	0.017	0.025	0.022	0.000	0.000	0.022	0.000
1994	0.067	0.406	0.664	0.433	0.153	0.068	0.021	0.000	0.006	0.000	0.000
1995	0.160	0.245	1.811	1.249	0.087	0.054	0.011	0.000	0.000	0.000	0.000
1996	0.022	0.240	0.196	0.414	0.143	0.060	0.027	0.000	0.000	0.000	0.000
1997	0.006	0.236	0.321	0.109	0.129	0.049	0.009	0.007	0.000	0.000	0.000
1998	0.070	0.336	1.026	0.352	0.041	0.035	0.004	0.000	0.004	0.000	0.000
1999	0.070	0.140	0.154	0.310	0.255	0.087	0.000	0.000	0.000	0.000	0.000
2000	0.020	0.571	0.538	0.071	0.079	0.031	0.000	0.000	0.000	0.000	0.000
2001	0.028	0.047	0.381	0.459	0.059	0.055	0.008	0.008	0.000	0.000	0.000
2002	0.234	0.478	0.707	1.396	1.627	0.118	0.131	0.012	0.000	0.000	0.000
2003	0.327	0.166	0.309	0.201	0.156	0.082	0.000	0.007	0.000	0.000	0.000
2004	1.6853	0.7448	0.1358	0.7101	0.252	0.3215	0.2524	0.0647	0.0195	0.000	0.000
average	0.360	1.318	1.066	0.728	0.421	0.146	0.126	0.063	0.051	0.029	0.056
											4.364

Table A3 continued. Stratified mean catch per tow at age (numbers) of Atlantic cod in Canadian spring bottom trawl survey

Year	AGE										No./ tow
	1	2	3	4	5	6	7	8	9	10+	
SPRING											
1986	0.60	2.27	2.81	0.37	0.65	0.44	0.26	0.04	0.07	0.03	7.54
1987	0.25	2.13	0.93	1.09	0.34	0.12	0.22	0.08	0.03	0.07	5.26
1988	0.28	1.01	4.66	0.58	1.02	0.13	0.08	0.17	0.04	0.07	8.04
1989	1.63	2.78	1.38	2.85	0.36	0.42	0.05	0.10	0.12	0.06	9.75
1990	0.42	2.44	3.78	2.08	3.87	0.42	0.93	0.12	0.12	0.35	14.53
1991	1.18	1.16	1.84	2.15	1.05	1.31	0.16	0.22	0.03	0.09	9.19
1992	0.11	2.86	1.77	0.80	0.98	0.60	0.43	0.12	0.07	0.02	7.76
*1993	0.05	0.60	2.83	1.04	0.62	1.23	0.44	0.42	0.07	0.12	7.42
*1994	0.02	0.80	0.89	1.65	0.60	0.23	0.45	0.11	0.15	0.04	4.94
1995	0.07	0.67	1.50	0.86	0.60	0.19	0.04	0.05	0.02	0.02	4.02
1996	0.14	0.49	2.31	4.02	1.09	0.79	0.33	0.08	0.11	0.03	9.39
1997	0.32	0.53	0.55	1.25	1.23	0.27	0.06	0.03	0.02	0.01	4.27
1998	0.01	0.67	0.95	0.35	0.35	0.28	0.07	0.02	0.00	0.02	2.72
1999	0.33	0.32	1.49	1.09	0.41	0.26	0.15	0.01	0.02	0.01	4.09
2000	0.10	0.44	1.05	3.92	1.71	0.78	0.40	0.24	0.01	0.03	8.68
2001	0.00	0.06	0.64	0.42	1.11	0.52	0.26	0.17	0.16	0.06	3.40
2002	0.01	0.09	0.57	2.05	0.68	1.22	0.40	0.17	0.05	0.08	5.32
2003	0.00	0.02	0.30	0.65	1.21	0.32	0.34	0.16	0.01	0.00	3.01
2004	0.54	0.10	0.39	0.42	0.45	0.39	0.07	0.12	0.02	0.01	2.50
*2005	0.05	2.04	2.78	14.18	3.42	1.59	1.45	0.12	0.15	0.02	25.80
average	0.31	1.07	1.67	2.09	1.09	0.58	0.33	0.13	0.06	0.06	6.41
* R/V Needler indices not included in VPA calibration (entire GB not surveyed)											
2005											
R/V Teleost	0.02	1.34	0.47	2.91	1.13	0.51	0.41	0.01	0.05	0.01	6.86

Table A4. USA sampling of commercial Atlantic cod landings, by market category, for the Georges Bank and South cod stock (NAFO Division 5Z and Subarea 6), 1978 □ 2004.

Year	Number of Samples, by Market Category & Quarter												Annual Sampling Intensity						
	Scrod					Market					Large				No. of Tons Landed/Sampled				
	Q1	Q2	Q3	Q4	Σ	Q1	Q2	Q3	Q4	Σ	Q1	Q2	Q3	Q4	Σ	Scrd	Mkt	Lge	Σ
1978	17	15	6	3	41	9	12	13	9	43	1	0	1	2	4	69	374	1922	302
1979	2	5	14	8	29	6	19	11	8	44	2	0	4	1	7	88	407	1742	408
1980	7	10	13	4	34	12	14	5	1	32	3	0	0	0	3	136	588	5546	580
1981	4	10	11	3	28	6	9	10	2	27	2	0	0	0	2	149	634	6283	594
1982	5	9	32	9	55	6	20	27	13	66	8	8	9	5	30	156	279	410	260
1983	4	12	17	10	43	12	19	22	14	67	2	15	16	3	36	185	291	259	252
1984	6	8	8	7	29	8	15	8	11	42	18	5	3	3	29	138	441	358	329
1985	6	7	16	5	34	11	11	12	8	42	4	8	7	5	24	201	299	310	268
1986	6	7	7	6	26	8	10	10	11	39	6	5	10	8	29	142	215	186	186
1987	7	8	6	8	29	6	8	9	10	33	6	6	4	2	18	240	220	267	238
1988	8	6	7	5	26	13	7	9	9	38	4	4	3	1	12	283	331	532	346
1989	2	7	9	9	27	7	8	8	7	30	3	4	1	1	9	210	450	660	380
1990	8	9	10	4	31	10	13	9	8	40	4	4	4	0	12	295	315	538	340
1991	6	11	7	5	29	12	13	8	8	41	4	6	3	5	18	158	293	423	275
1992	6	7	7	10	30	8	10	6	9	33	5	5	3	1	14	149	215	377	219
1993	5	16	7	6	34	10	10	7	9	36	6	1	3	2	12	126	173	339	178
1994	3	9	8	2	22	5	11	7	4	27	1	4	3	1	9	92	187	290	167
1995	2	3	13	2	20	2	4	10	2	18	0	1	0	1	2	83	181	880	167
1996	6	2	12	3	23	5	6	11	6	28	0	2	1	1	4	59	143	400	127
1997	3	11	3	10	27	5	16	9	9	39	3	6	0	5	14	50	105	148	94
1998	3	7	23	5	38	10	10	15	3	38	1	2	1	0	3	44	92	573	88
1999	5	3	10	3	21	7	14	10	7	38	2	5	2	0	9	80	118	205	118
2000	21	19	16	27	83	20	14	13	16	63	2	2	2	2	8	18	72	192	49
2001	11	9	13	3	36	9	10	8	10	37	6	12	6	10	34	72	163	55	98
2002	5	7	7	1	20	8	10	11	6	35	14	8	6	3	31	80	153	63	104
2003	4	8	6	10	28	7	16	10	6	39	5	11	10	4	30	21	113	52	68
2004	8	11	4	10	33	13	9	7	14	43	24	12	2	11	49	8	50	20	27

Table A5. Landings at age (thousands of fish; metric tons) and mean weight (kg) and mean length (cm) at age of total commercial landings of Atlantic cod from the Georges Bank and South stock (NAFO Division 5Z and Subarea 6), 1978–2004.

Year	Age										% of Total Landings		
	1	2	3	4	5	6	7	8	9	10+	Total	USA	Canada
<u>Total Commercial Landings in Numbers (000's) at Age</u>													
1978	2	392	7708	2290	826	129	344	47	40	15	11793	74.1	26.4
1979	34	1989	900	4870	1212	458	77	253	4	48	9845	81.2	18.8
1980	89	3778	5829	500	2308	1076	445	87	167	10	14289	80.9	19.1
1981	27	3206	4224	2466	236	1408	417	123	130	62	12299	84.1	15.8
1982	331	9142	3828	2790	2002	281	674	213	71	83	19416	74.1	25.9
1983	108	4286	8062	2456	1055	776	95	235	100	65	17237	72.2	27.8
1984	81	1307	3423	3337	841	516	458	44	171	121	10300	89.0	11.0
1985	134	6427	2443	1368	1885	412	218	203	21	97	13209	68.4	31.6
1986	156	1329	4588	801	482	630	87	72	47	29	8221	71.5	28.2
1987	26	7474	1406	2121	279	252	270	63	38	24	11953	64.2	35.8
1988	10	1574	7992	1008	1492	243	160	196	50	47	12770	71.8	28.6
1989	0	2084	2919	4145	330	539	82	43	50	18	10209	81.3	18.9
1990	7	4943	5049	1884	2267	229	245	36	17	38	14716	74.2	25.7
1991	52	1525	3243	3282	1458	1088	126	70	23	23	10891	67.7	32.3
1992	70	4171	2167	1037	1480	403	308	34	33	10	9714	58.8	41.3
1993	4	1033	4247	1115	440	472	159	143	32	17	7662	67.0	33.0
1994	2	398	1526	1826	394	96	137	46	38	6	4470	68.4	31.5
1995	0	393	1059	693	291	45	26	15	2	1	2525	86.7	13.1
1996	1	208	907	1240	242	124	15	2	4	0	2743	79.7	19.9
1997	3	517	640	884	795	132	84	15	10	4	3084	74.0	25.8
1998	0	740	1191	424	326	239	39	13	7	5	2984	81.7	18.0
1999	1	286	1926	706	201	97	119	17	2	3	3359	83.7	16.3
2000	14	752	687	1062	284	75	42	37	4	1	2958	84.5	15.5
2001	0	685	2382	643	597	166	45	22	11	2	4554	86.4	13.6
2002	0	51	967	1347	318	331	67	17	8	5	3111	89.4	10.6
2003	0.2	71	371	754	751	124	122	23	6	3	2226	83.3	16.7
2004	0	31	319	222	264	230	49	41	10	4	1170	74.7	25.3

Table A5 - continued. Landings at age (thousands of fish; metric tons) and mean weight (kg) and mean length (cm) at age of total commercial landings of Atlantic cod from the Georges Bank and South stock (NAFO Division 5Z and Subarea 6), 1978–2004.

Year	Age										% of Total Landings		
	1	2	3	4	5	6	7	8	9	10+	Total	USA	Canada
<u>Total Commercial Landings in Weight (Tons) at Age</u>													
1978	1	513	18975	7952	3581	750	2539	394	467	186	35357	75.2	24.8
1979	30	2971	1936	20504	5923	3285	710	2612	47	606	38623	84.5	15.5
1980	75	5517	14385	1834	13038	7185	3732	790	1404	157	48116	83.2	16.8
1981	24	4790	9960	8424	1226	10167	3578	1215	1849	1115	42348	79.9	20.1
1982	253	12819	10198	10695	10717	1832	6306	2117	891	1330	57157	68.8	31.2
1983	104	6387	19166	8124	4891	4963	759	2420	1122	951	48886	75.2	24.8
1984	85	2137	8389	12076	4274	3400	4079	448	1934	1855	38678	85.1	14.9
1985	121	9112	5096	5319	9590	2641	1765	2076	242	1309	37271	72.0	28.0
1986	145	1959	11232	2934	2701	4525	781	719	597	400	25994	67.3	32.4
1987	19	11072	3509	8884	1620	1945	2419	635	431	344	30879	61.6	38.4
1988	8	2394	18847	3537	8052	1613	1405	1949	556	690	39051	67.4	33.1
1989	0	3370	6626	15631	1777	3611	667	453	584	273	32992	76.1	24.3
1990	5	7711	12431	6638	11091	1450	2072	382	223	554	42557	66.2	33.6
1991	59	2481	8266	11223	6956	6413	933	736	223	346	37637	64.2	35.7
1992	80	6432	5340	3988	6963	2482	2318	333	401	192	28528	59.1	41.1
1993	3	1585	9567	3718	2184	3013	1195	1315	316	220	23118	63.1	36.9
1994	2	581	3309	6676	1892	716	1096	430	364	102	15171	65.2	34.8
1995	0	572	2221	2652	1599	328	273	175	21	20	7859	86.0	13.8
1996	1	313	2209	4201	1190	823	128	21	59	2	8946	78.5	21.0
1997	3	817	1484	3120	3263	792	676	135	112	53	10456	72.1	27.7
1998	0	1098	2743	1483	1539	1417	325	118	82	61	8867	78.5	21.1
1999	1	446	4283	2437	986	622	874	160	26	45	9880	81.6	18.4
2000	13	1275	1690	3752	1345	436	317	322	30	8	9189	82.9	17.1
2001	0	1036	5594	2029	2604	915	284	183	110	18	12778	83.2	16.8
2002	0	91	2189	4134	1364	1771	453	141	74	57	10274	87.6	12.4
2003	0.1	138	874	2287	3029	615	754	186	51	28	7963	83.5	16.5
2004	0	60	826	707	1082	1157	291	322	90	51	4583	75.7	24.3

Table A5- continued. Landings at age (thousands of fish; metric tons) and mean weight (kg) and mean length (cm) at age of total commercial landings of Atlantic cod from the Georges Bank and South stock (NAFO Division 5Z and Subarea 6), 1978□2004.

Year	Age										
	1	2	3	4	5	6	7	8	9	10+	Mean
<u>Total Commercial Landings Mean Weight (kg) at Age</u>											
1978	0.707	1.310	2.461	3.469	4.336	5.787	7.374	8.492	11.785	13.200	2.983
1979	0.889	1.494	2.149	4.211	4.888	7.178	9.183	10.313	11.699	12.625	3.923
1980	0.836	1.460	2.468	3.668	5.647	6.676	8.390	9.089	8.432	15.400	3.368
1981	0.882	1.495	2.358	3.415	5.213	7.222	8.565	9.888	14.170	18.565	3.446
1982	0.765	1.402	2.664	3.834	5.352	6.511	9.363	9.897	12.503	16.723	2.946
1983	0.971	1.490	2.377	3.309	4.637	6.393	7.964	10.286	11.227	14.554	2.836
1984	1.053	1.635	2.451	3.619	5.083	6.582	8.909	10.104	11.303	15.356	3.756
1985	0.907	1.418	2.086	3.887	5.087	6.412	8.097	10.236	11.418	13.494	2.822
1986	0.929	1.475	2.447	3.660	5.603	7.191	8.915	9.955	12.687	14.104	3.161
1987	0.726	1.481	2.495	4.187	5.810	7.726	8.949	10.013	11.414	15.000	2.584
1988	0.786	1.520	2.359	3.511	5.401	6.647	8.776	9.987	11.143	15.298	3.062
1989	-	1.617	2.269	3.772	5.396	6.694	8.222	10.718	11.665	17.111	3.235
1990	0.831	1.560	2.462	3.522	4.892	6.333	8.456	10.648	12.580	14.526	2.891
1991	1.114	1.627	2.548	3.420	4.769	5.891	7.410	10.520	9.686	15.373	3.456
1992	1.148	1.542	2.464	3.843	4.704	6.156	7.509	9.846	12.059	19.025	2.937
1993	0.872	1.534	2.253	3.333	4.967	6.379	7.510	9.217	9.699	13.236	3.017
1994	0.906	1.459	2.168	3.657	4.804	7.432	8.013	9.368	9.698	16.659	3.394
1995	0.906	1.471	2.095	3.830	5.492	7.384	10.715	11.617	10.383	14.953	3.087
1996	0.882	1.507	2.435	3.387	4.912	6.622	8.369	8.438	12.883	12.002	3.212
1997	0.954	1.577	2.321	3.532	4.103	6.019	8.050	8.631	11.870	12.795	3.390
1998	0.579	1.483	2.302	3.497	4.735	5.934	8.185	8.610	12.684	14.606	2.969
1999	0.830	1.565	2.223	3.452	4.891	6.422	7.341	9.685	12.153	13.735	2.941
2000	0.956	1.696	2.461	3.533	4.731	5.797	7.530	8.596	8.817	12.831	3.107
2001	0.880	1.516	2.349	3.157	4.356	5.516	6.323	8.178	9.766	11.951	2.806
2002	0.551	1.768	2.265	3.068	4.290	5.345	6.759	8.428	9.711	12.127	3.303
2003	0.524	1.941	2.353	3.034	4.031	4.954	6.178	7.924	9.239	10.793	3.577
2004	0.704	1.950	2.586	3.192	4.090	5.032	5.945	7.838	9.273	12.219	3.920

Table A5 - continued. Landings at age (thousands of fish; metric tons) and mean weight (kg) and mean length (cm) at age of total commercial landings of Atlantic cod from the Georges Bank and South stock (NAFO Division 5Z and Subarea 6), 1978–2004.

Year	Age										Mean
	1	2	3	4	5	6	7	8	9	10+	
<u>Total Commercial Landings Mean Length (cm) at Age</u>											
1978	39.5	50.0	60.8	67.9	72.7	80.4	80.2	93.1	103.4	106.5	64.1
1979	44.7	52.2	57.7	73.2	76.8	87.5	95.3	99.5	103.4	106.4	69.6
1980	43.8	51.8	61.2	69.7	80.9	86.0	92.4	93.8	92.4	114.6	65.6
1981	44.4	52.2	60.2	68.4	78.2	88.0	93.5	97.5	110.3	119.5	65.6
1982	42.2	51.2	62.4	70.5	79.1	84.3	96.0	97.4	105.8	115.0	61.9
1983	45.5	52.3	60.4	67.0	75.3	84.4	90.7	99.1	101.9	111.4	62.4
1984	47.2	54.0	61.5	69.8	77.8	85.5	94.4	98.6	102.3	112.8	68.6
1985	44.9	51.1	57.5	71.4	78.0	84.3	91.3	98.8	102.3	108.2	61.1
1986	45.0	51.9	61.1	69.2	80.7	87.7	94.4	98.0	105.9	108.4	64.3
1987	40.7	51.8	61.2	73.0	81.8	90.1	94.5	98.2	102.5	111.2	59.7
1988	40.8	52.8	60.4	68.5	79.5	85.3	93.6	97.7	101.5	111.2	64.1
1989	0.0	53.8	60.0	70.4	79.2	85.2	91.7	100.3	103.2	113.3	65.7
1990	41.7	53.5	61.0	68.7	76.6	83.2	92.1	100.2	106.0	110.8	62.9
1991	47.7	53.6	62.2	67.7	75.8	80.9	87.8	99.4	95.9	113.9	67.0
1992	46.2	52.4	60.8	70.6	75.1	82.2	87.9	96.0	104.3	116.0	62.4
1993	42.2	52.7	59.6	67.0	76.3	83.6	88.2	95.1	95.9	107.0	63.0
1994	43.1	51.7	58.9	69.6	75.8	88.2	90.7	95.3	95.9	115.8	65.8
1995	43.0	50.6	58.2	70.9	80.5	88.5	100.9	103.8	99.1	113.0	64.6
1996	45.1	52.7	61.2	68.0	76.9	85.5	90.7	91.0	106.9	104.6	66.4
1997	43.7	53.4	60.2	68.8	72.1	82.3	91.2	93.1	104.2	106.5	66.7
1998	37.8	52.4	60.1	68.8	76.0	82.2	91.4	93.1	106.4	111.9	61.7
1999	41.5	53.4	59.6	68.6	76.9	84.1	88.5	96.6	103.4	109.0	64.0
2000	45.4	54.9	61.8	69.4	76.3	81.5	89.2	93.7	93.8	107.9	65.4
2001	43.0	53.1	60.8	66.7	74.1	80.2	83.6	91.4	97.5	103.6	63.4
2002	37.0	55.8	60.1	66.2	73.8	79.3	85.6	92.0	96.5	104.2	67.0
2003	36.5	57.4	61.0	66.1	72.4	77.2	83.4	90.8	95.5	100.3	69.0
2004	40.1	57.6	62.7	67.1	72.8	77.9	82.3	90.5	95.5	104.8	70.9

Table A6. Estimates of beginning year stock size (thousands of fish), instantaneous fishing mortality (F), spawning stock biomass (mt), and percent mature of Georges Bank cod, estimated from virtual population analysis (VPA), calibrated using the commercial catch at age ADAPT formulation, 1978-2004.

Stock Numbers (Jan 1) in thousands

Age	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
1	27713	23513	20104	41392	17471	9615	27391	8669	42747	16376	23446	15673	9184	17849
2	4268	22688	19220	16380	33865	14004	7774	22353	6977	34857	13384	19187	12832	7513
3	25526	3139	16776	12319	10510	19458	7588	5182	12486	4512	21777	9531	13819	6034
4	7947	13888	1755	8461	6266	5145	8635	3115	2032	6085	2422	10571	5159	6752
5	2878	4422	6964	985	4698	2609	1990	4051	1312	943	3063	1067	4895	2521
6	1124	1605	2524	3613	594	2037	1181	869	1611	640	519	1153	574	1959
7	1434	802	900	1093	1686	232	965	500	339	752	296	205	455	263
8	67	862	587	334	517	772	104	376	212	199	371	97	93	151
9	146	12	477	402	162	231	419	45	124	109	106	126	40	44
10+	55	149	29	192	189	150	297	209	77	69	99	45	90	44
Total	71158	71082	69336	85171	75959	54252	56344	45370	67918	64541	65483	57654	47142	43129
Age	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
1	6641	8183	5252	3248	5928	10096	4577	12809	7928	3436	3352	2283	21220	10398
2	14566	5374	6696	4298	2659	4852	8263	3747	10486	6478	2813	2745	1869	17373
3	4771	8147	3465	5122	3165	1990	3505	6097	2810	7904	4684	2257	2183	1502
4	2006	1943	2828	1456	3236	1774	1051	1795	3248	1679	4316	2960	1512	1499
5	2559	703	582	664	566	1533	655	478	831	1698	793	2315	1741	1037
6	745	755	178	120	281	245	537	243	209	423	850	361	1216	1187
7	620	244	191	58	58	119	82	225	111	103	196	397	184	787
8	101	228	56	32	24	34	21	32	77	53	44	100	214	106
9	60	52	57	4	13	17	13	5	12	29	24	21	61	139
10+	18	28	9	2	0	2	9	7	3	5	15	10	21	53
Total	32088	25656	19313	15005	15930	20662	18714	25438	25713	21810	17087	13448	30220	34081

Table A6 - continued

Fishing Mortality

	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
Age	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	
1	0.00	0.00	0.00	0.00	0.02	0.01	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00
2	0.11	0.10	0.24	0.24	0.35	0.41	0.21	0.38	0.24	0.27	0.14	0.13	0.55	0.25
3	0.41	0.38	0.48	0.48	0.51	0.61	0.69	0.74	0.52	0.42	0.52	0.41	0.52	0.90
4	0.39	0.49	0.38	0.39	0.68	0.75	0.56	0.66	0.57	0.49	0.62	0.57	0.52	0.77
5	0.38	0.36	0.46	0.31	0.64	0.59	0.63	0.72	0.52	0.40	0.78	0.42	0.72	1.02
6	0.14	0.38	0.64	0.56	0.74	0.55	0.66	0.74	0.56	0.57	0.73	0.73	0.58	0.95
7	0.31	0.11	0.79	0.55	0.58	0.60	0.74	0.66	0.33	0.51	0.92	0.59	0.91	0.75
8	1.48	0.39	0.18	0.52	0.61	0.41	0.63	0.91	0.47	0.43	0.88	0.68	0.56	0.72
9	0.36	0.43	0.48	0.44	0.65	0.64	0.59	0.71	0.53	0.48	0.72	0.57	0.62	0.85
10+	0.36	0.43	0.48	0.44	0.65	0.64	0.59	0.71	0.53	0.48	0.72	0.57	0.62	0.85
Total	0.54	0.35	0.49	0.47	0.65	0.58	0.64	0.74	0.49	0.48	0.79	0.60	0.65	0.84
Age	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	
1	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0.38	0.24	0.07	0.11	0.09	0.13	0.10	0.09	0.08	0.12	0.02	0.03	0.02	
3	0.70	0.86	0.67	0.26	0.38	0.44	0.47	0.43	0.31	0.41	0.26	0.20	0.18	
4	0.85	1.01	1.25	0.74	0.55	0.80	0.59	0.57	0.45	0.55	0.42	0.33	0.18	
5	1.02	1.18	1.38	0.66	0.64	0.85	0.79	0.63	0.47	0.49	0.59	0.44	0.18	
6	0.91	1.18	0.91	0.52	0.66	0.89	0.67	0.58	0.50	0.57	0.56	0.48	0.23	
7	0.80	1.27	1.58	0.68	0.34	1.52	0.74	0.88	0.54	0.66	0.47	0.42	0.35	
8	0.46	1.18	2.37	0.72	0.15	0.73	1.29	0.80	0.76	0.61	0.56	0.29	0.24	
9	0.91	1.09	1.27	0.71	0.56	0.84	0.67	0.61	0.46	0.53	0.46	0.39	0.24	
10+	0.91	1.09	1.27	0.71	0.56	0.84	0.67	0.61	0.46	0.53	0.46	0.39	0.24	
Total	0.81	1.16	1.50	0.67	0.47	0.96	0.82	0.69	0.55	0.58	0.52	0.39	0.24	

Table A6 continued. Estimates of beginning year stock size (thousands of fish), instantaneous fishing mortality (F), spawning stock biomass (mt), and percent mature of Georges Bank cod, estimated from virtual population analysis (VPA), calibrated using the commercial catch at age ADAPT formulation, 1978-2004.

SSB at start of spawning season

Age	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
1	913	1104	850	1960	1200	903	3123	773	8512	2224	3479	2473	633	1961
2	1410	7539	6913	5782	16137	6344	4303	11650	5027	25329	8902	13721	6610	4211
3	33845	3729	22417	15928	15642	26058	10500	6878	18776	7101	32836	14540	22024	9011
4	20219	38255	4297	21379	15793	12648	21655	8075	4842	17024	6128	27180	12814	16501
5	8798	16585	30442	3958	17473	9639	7110	14906	5434	3937	12377	4189	18051	8432
6	4882	8130	12541	20322	2957	10520	5655	4242	8582	3704	2764	5937	2947	8681
7	8215	5550	5918	7296	12172	1460	6226	3166	2345	5361	2024	1327	2845	1537
8	367	6810	5034	2696	4165	6840	811	2985	1705	1691	2930	811	769	1218
9	1331	112	3967	4100	1564	2116	3961	417	1252	1034	958	1193	409	373
10+	659	1698	392	3199	2750	1899	3992	2422	956	919	1304	681	1143	565
Total	80639	89512	92771	86621	89852	78426	67335	55513	57432	68324	73700	72053	68245	52490
Age	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
1	764	640	72	44	76	971	203	935	175	62	29	42	705	
2	9011	3447	2817	1839	1155	3090	5325	1938	5222	3251	1488	929	619	
3	7401	11456	5195	7881	5166	3078	5495	9169	4808	13550	7638	3402	3633	
4	5218	4508	6375	3584	7612	4406	2625	4450	8169	4129	10444	6818	3743	
5	8375	2442	1788	2578	2136	4798	2271	1721	3000	5938	2559	7313	5756	
6	3351	3286	896	632	1469	1112	2292	1177	990	1901	3614	1488	5093	
7	3488	1300	1013	451	418	652	494	1241	685	543	1071	2056	911	
8	775	1504	307	266	219	248	139	242	518	364	283	674	1383	
9	561	411	422	37	137	145	121	43	96	237	188	165	483	
10+	287	296	117	28	0	21	113	87	34	56	160	100	237	
Total	39229	29289	19003	17340	18387	18521	19078	21003	23697	30033	27474	22987	22564	

Table A6 continued

Percent mature (females)

	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
Age														
1	7	7	7	7	13	13	13	13	28	28	28	28	12	12
2	34	34	34	34	47	47	47	47	67	67	67	67	52	52
3	78	78	78	78	84	84	84	84	91	91	91	91	90	90
4	96	96	96	96	97	97	97	97	98	98	98	98	99	99
5+	100	100	100	100	100	100	100	100	100	100	100	100	100	100

	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	
Age														
1	12	12	12	2	2	2	13	13	13	3	3	7	7	7
2	52	52	52	39	39	39	57	57	57	44	44	34	34	34
3	90	90	90	95	95	95	92	92	92	95	95	79	79	79
4	99	99	99	100	100	100	100	100	100	100	100	96	96	96
5+	100	100	100	100	100	100	100	100	100	100	100	100	100	100

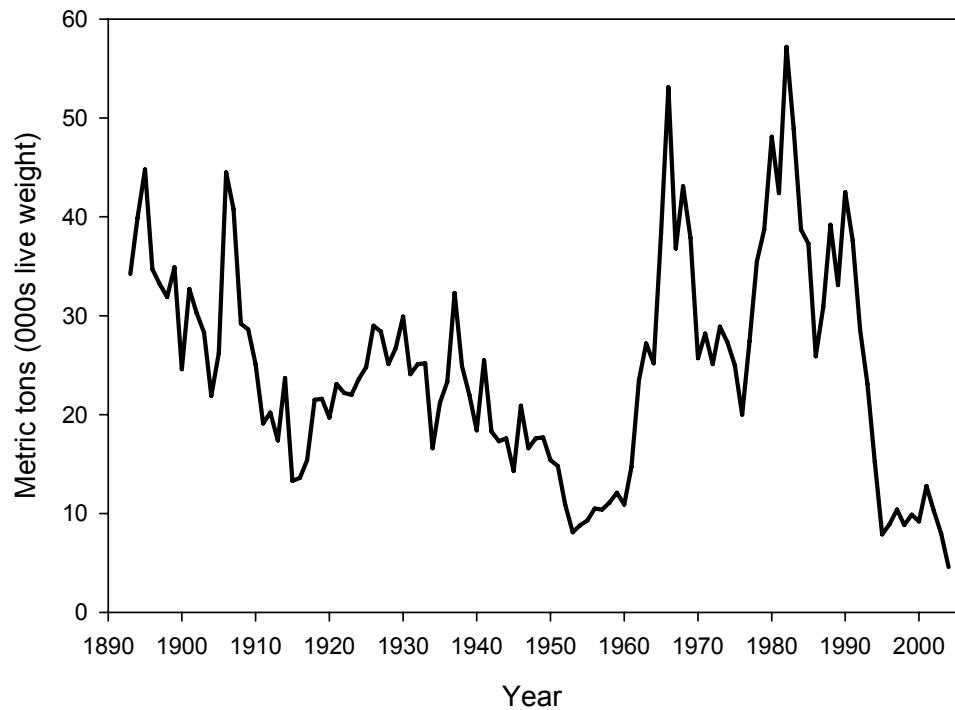


Figure A1a. Total commercial landings of Georges Bank cod (NAFO Division 5Z ans Subarea 6), 1893-2004.

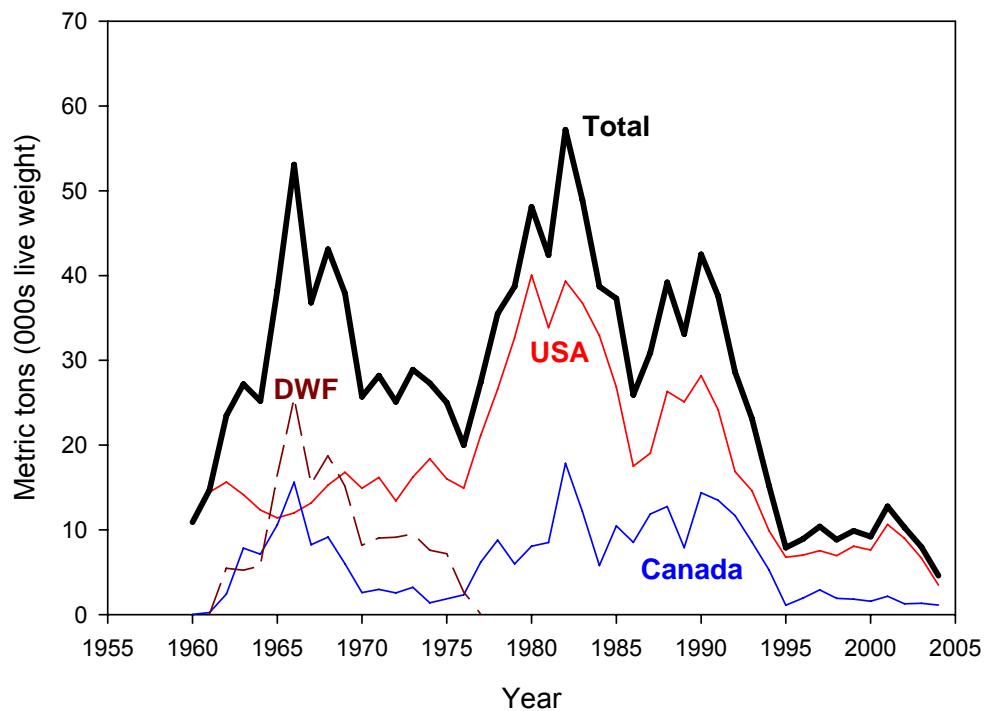


Figure A1b. Total commercial landings of Georges Bank cod (NAFO Division 5Z ans Subarea 6), 1960-2004.

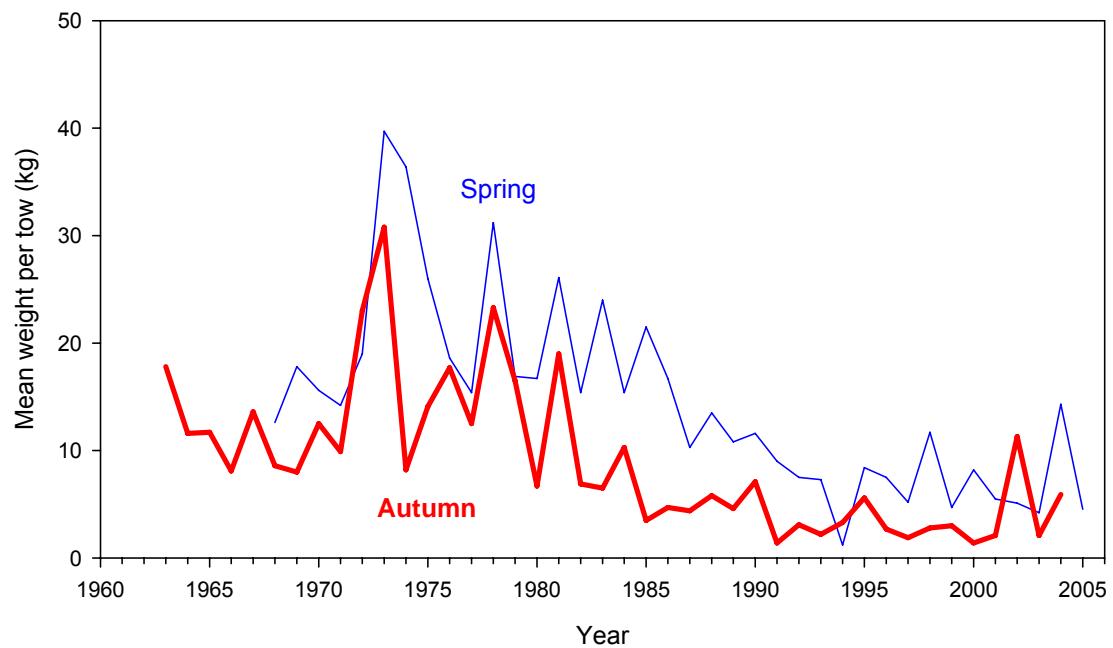


Figure A2. Standardized stratified mean catch per tow (kg) of Atlantic cod in NEFSC spring and autumn research vessel bottom trawl surveys on Georges Bank, 1963-2005.

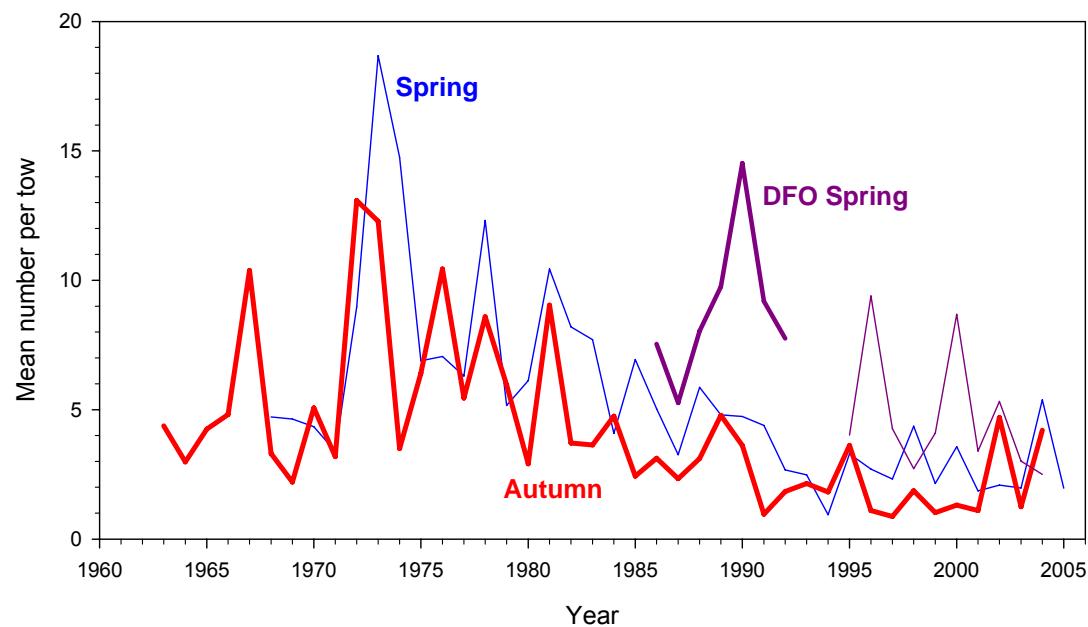


Figure A3. Standardized stratified mean number per tow of Atlantic cod in NEFSC and DFO spring and NEFSC autumn research vessel bottom trawl surveys on Georges Bank, 1963-2005.

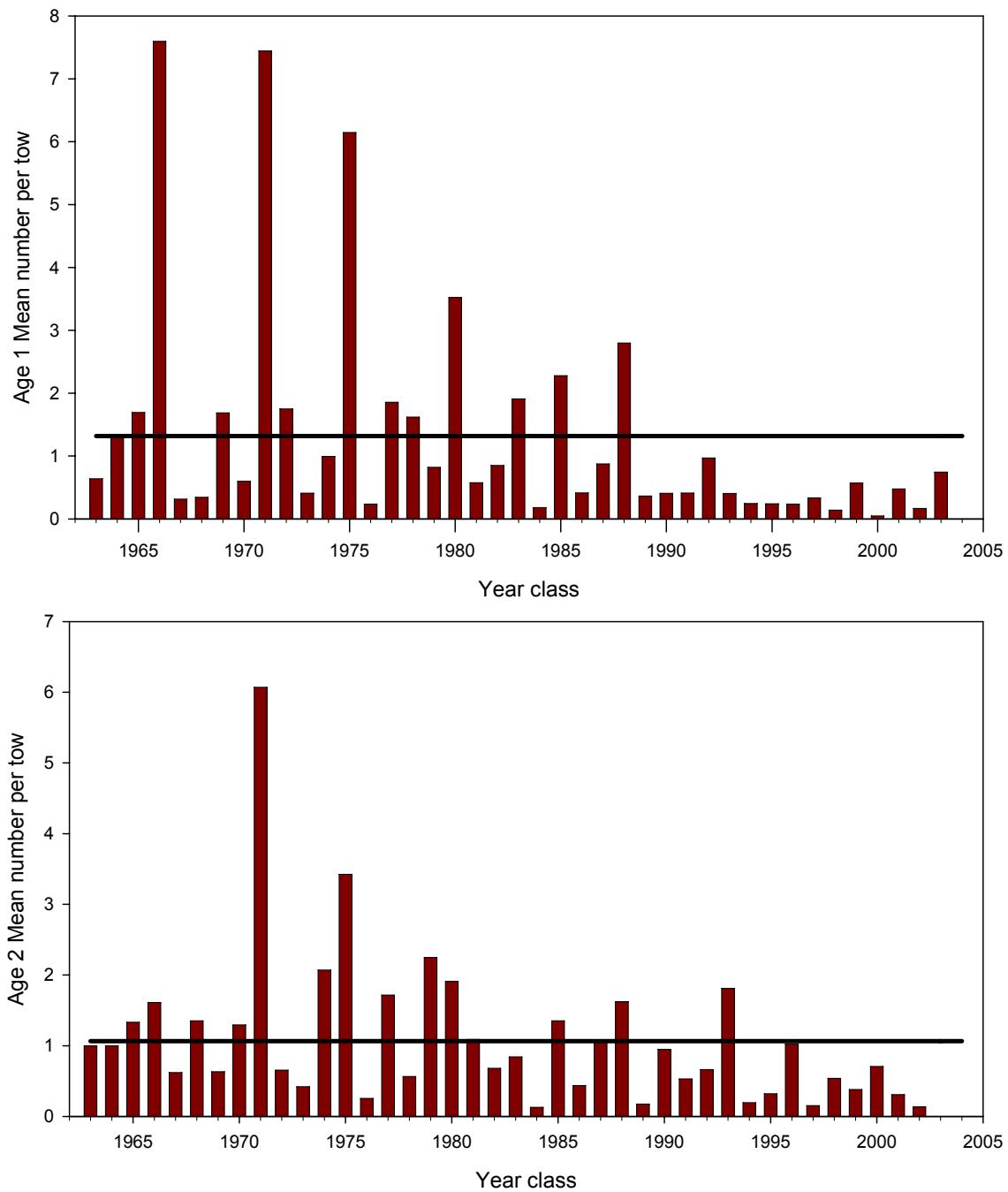


Figure A4. Relative year class strength of age 1 and age 2 Georges Bank cod based on standardized catch (number) per tow indices from NEFSC autumn research vessel bottom trawl surveys, 1963-2004. Horizontal line represents the time series average.

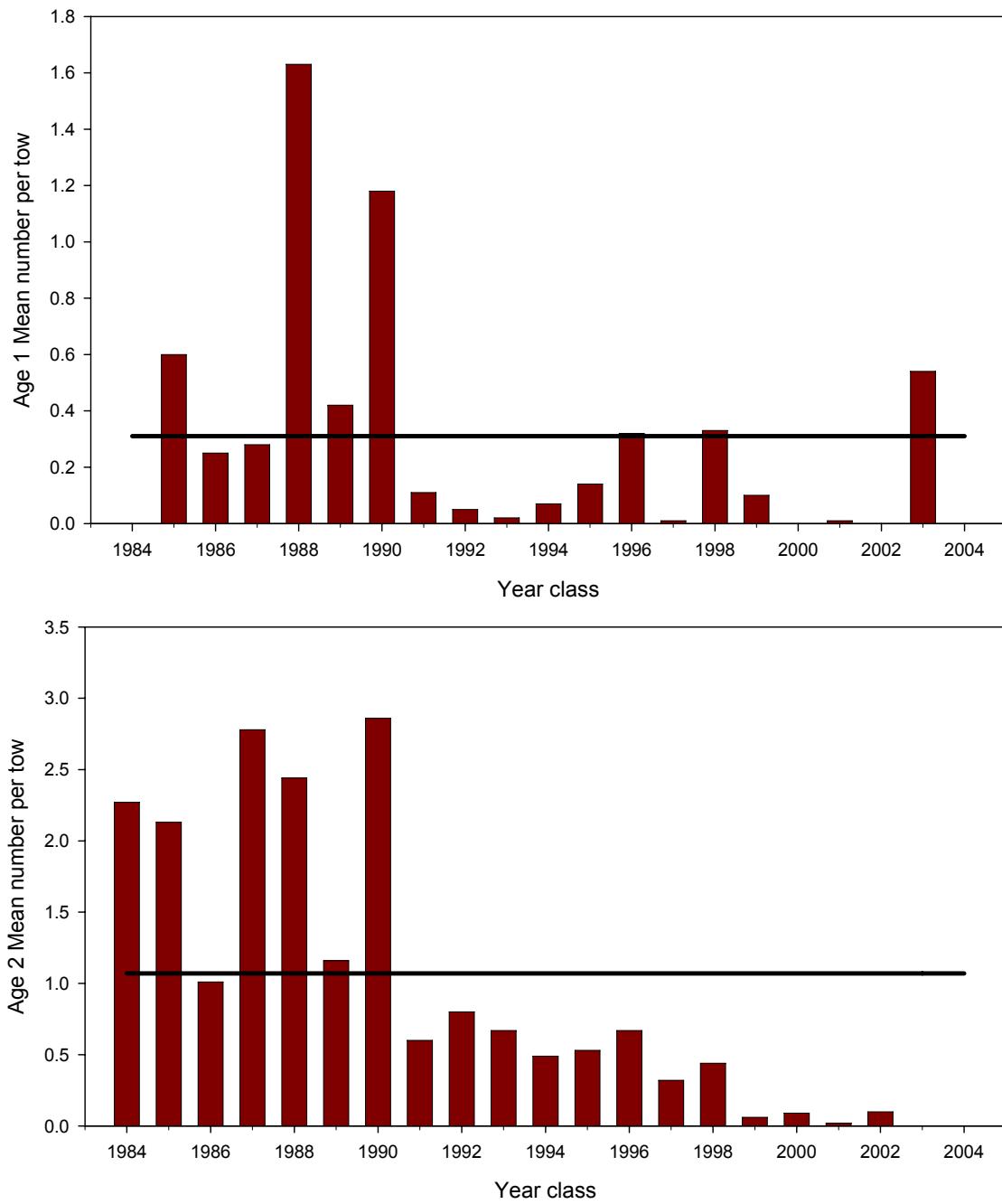


Figure A5. Relative year class strength of age 1 and age 2 Georges Bank cod based on standardized catch (number) per tow indices from DFO spring research vessel bottom trawl surveys, 1986–2004. Horizontal line represents the time series average.

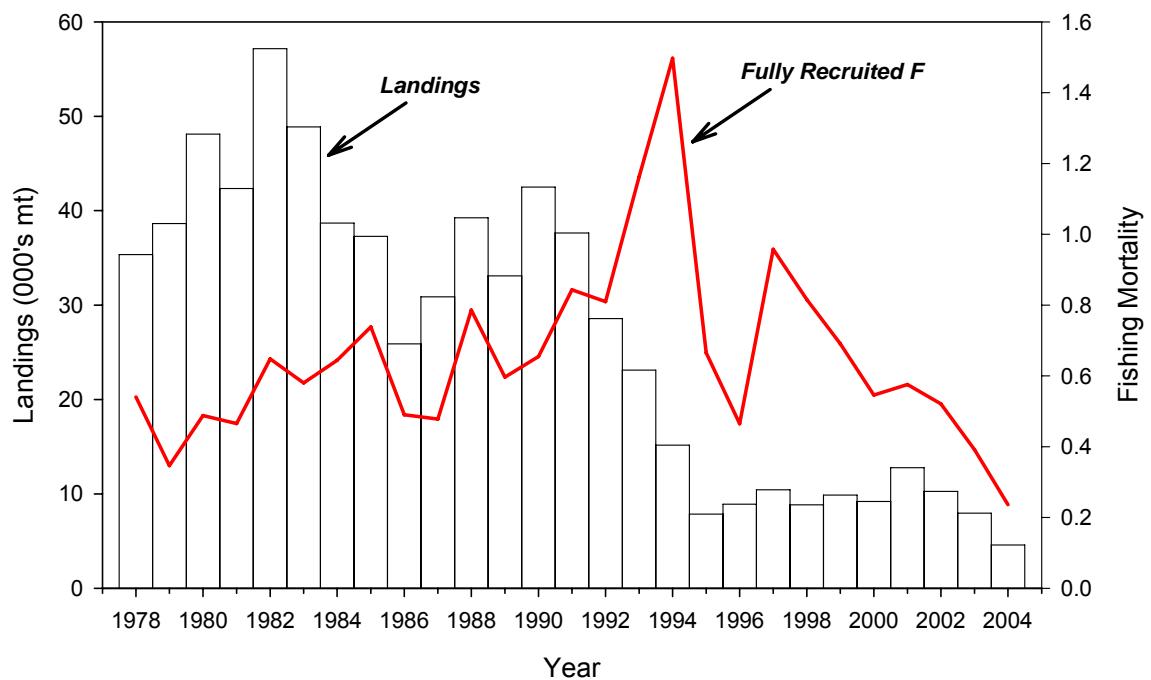


Figure A6. Trends in total commercial landings and fishing mortality for Georges Bank cod, 1978-2005.

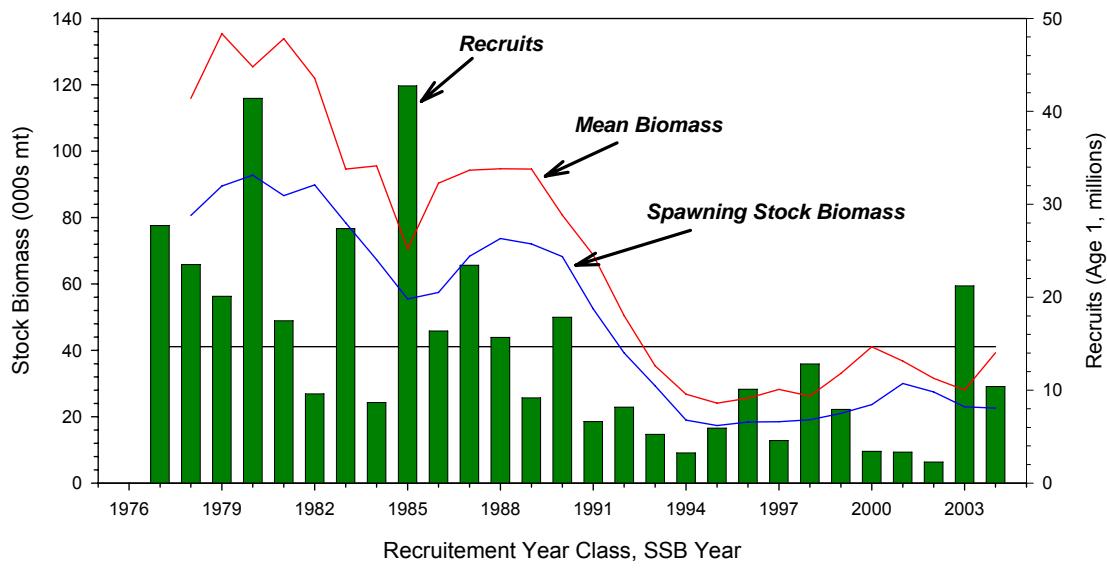


Figure A7. Trends in stock biomass and recruitment for Georges Bank Atlantic cod, 1978-2004.
Horizontal line is the average recruitment for the time series.

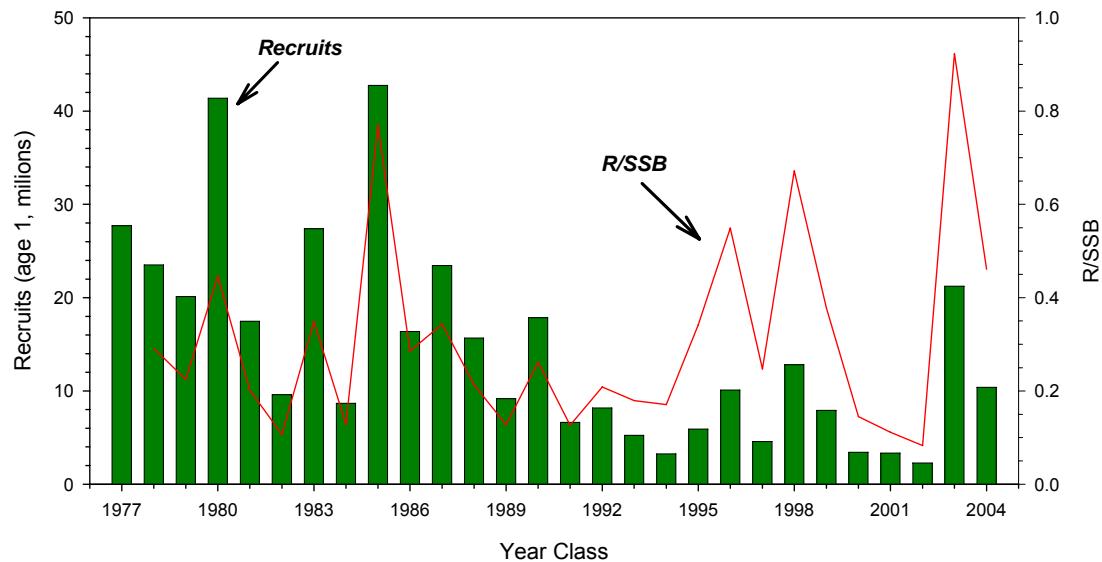


Figure A8. Trends in recruitment and recruitment/SSB survival ratio for Georges Bank cod, 1978-2004.

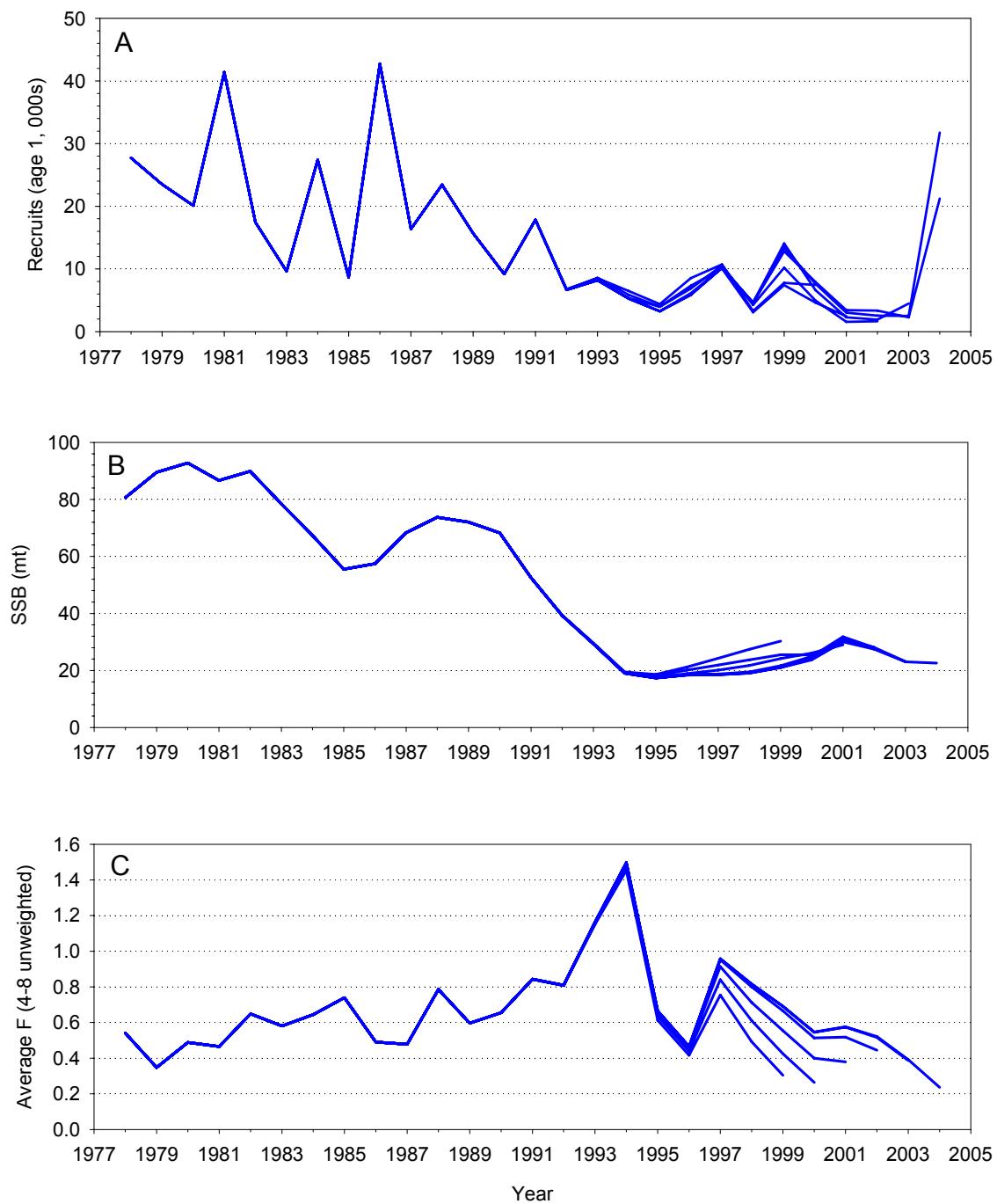
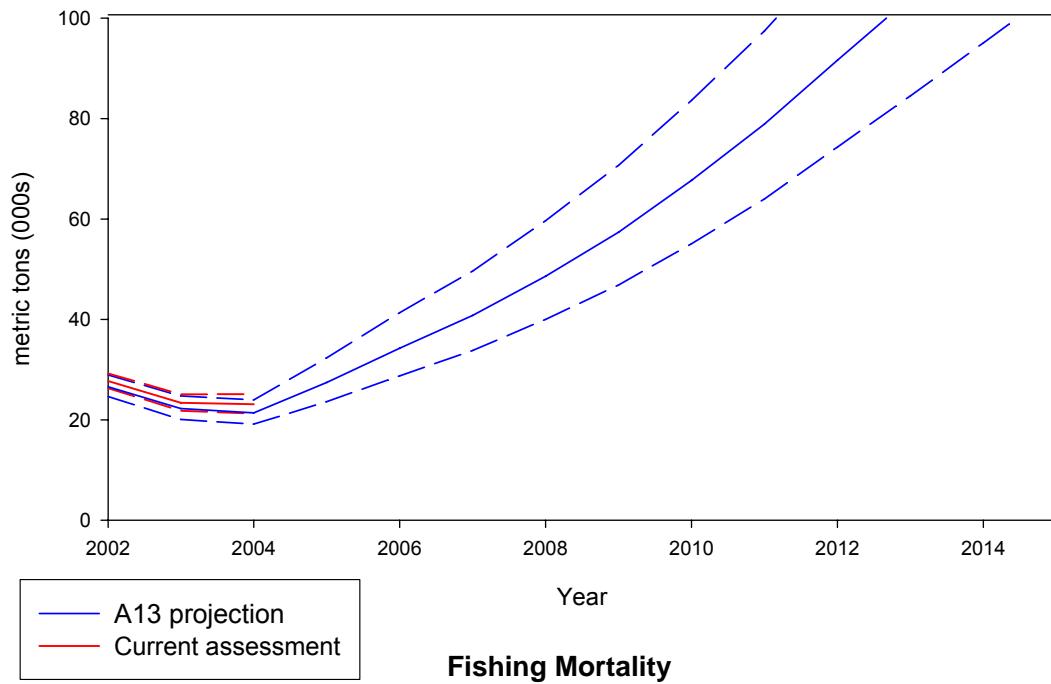


Figure A9. Retrospective analysis of Georges Bank cod recruits at age 1(A), spawning stock biomass (B), and fishing mortality (C) (average F, aged 4-8, unweighted), based on the final ADAPT VPA formulation, 2004-1995.

GB Cod Spawning Stock Biomass



Fishing Mortality

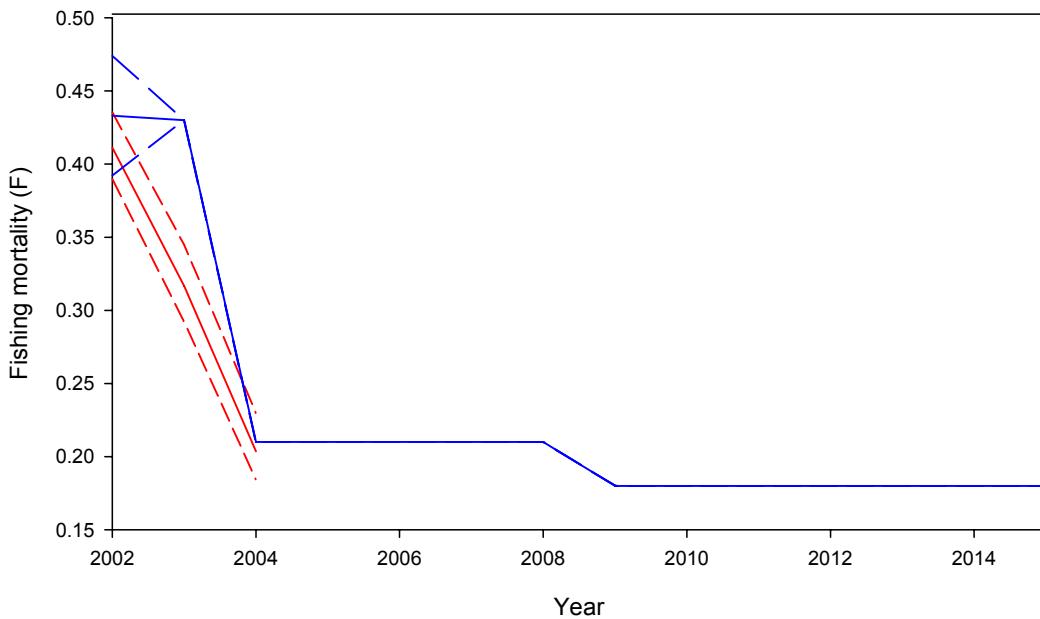


Figure A10. Comparison of A13 projections and current assessment bootstrap estimates of spawning stock biomass (SSB) and fishing mortality (F), 2002-2004.